CLAIMS:

1. A system for measuring a parameter of a device at a first location comprising:

a sensor for measuring the device parameter and generating a data signal representing the measured parameter;

a microprocessor coupled to the sensor for activating the sensor on a first periodic basis to measure the device parameter;

a memory in the microprocessor for storing the generated data signal representing the measured parameter;

a transmitter coupled to the microprocessor; and

a receiver coupled to the microprocessor, the microprocessor periodically partially awakening to determine, on a second periodic basis, if a received transmission is a valid interrogation signal and, if so, fully awakening and responding to the valid interrogation signal, via the transmitter, by at least transmitting the last stored measured parameter.

2. The system of claim 1, further including a remote computer at a third location for receiving data from the second location via a communication channel.

3. The system of claim 2, wherein the communication channel is selected from the group consisting of a wire link, wireless link, RF link, cable link, microwave link, satellite link, optical link, LAN link, Internet link, and Ethernet link.

4. The system of claim 1, further comprising:

a reader/transceiver (RT) at the second location for receiving signals from the device and transmitting signals to the device;

a reader processor (RP) for receiving and interpreting the signals from the device; and

a computer for communicating with the RP and enabling a user to access data from the device.

5. The system of claim 4, wherein the computer is a field support computer.

6. The system of claim 4, wherein the computer is a remote computer.

7. The system of claim 4, wherein the computer is a personal computer.

8. The system of claim 4, wherein the RP and the RT are both at the second location.

9. The system of claim 4, wherein the RP is remote from the second location.

10. The system of claim 4, wherein the RT is capable of interrogating the device to obtain data including at least temperature and pressure.

11. The system of claim 4, wherein the RT is capable of interrogating the device to obtain data including number of tire rotations.

12. The system of claim 1, wherein the device is a tire tag.

13. The system of claim 12, further including reader/transceiver (RT) units on each side of a vehicle, each RT unit communicating with one or more tire tags on the same side of the vehicle on which the RT unit is located.

14. The system of claim 12, wherein the tire tag is a self-powered unit.

15. The system of claim 1, wherein the device is a tire tag disposed inside of a vehicle tire, and further comprising:

a printed circuit board (PCB) disposed within the vehicle tire, the PCB including first antenna terminals, the sensor, the microprocessor, the memory, and the transmitter;

an antenna disposed in the vehicle tire and including second antenna terminals, the first and second antenna terminals being configured to electrically connect with each other to thereby electrically connect the antenna to the transmitter, the antenna being spaced from the PCB; and

potting material for encapsulating the PCB, the sensor, the microprocessor, the memory, the transmitter, and the antenna.

16. The system of claim 15, wherein the antenna includes first and second elements.

17. The system of claim 15, wherein the antenna is a dipole antenna.

18. The system of claim 1, further comprising:

a reader/transceiver (RT) at the second location for receiving signals from the device and transmitting signals to the device;

a memory in the RT for storing the received data signal; and

a microprocessor in the RT for controlling the memory, data reception and data transmission.

19. The system of claim 18, wherein the second location is remote from the device, the RT transmitting forward link signals to the device and receiving return link signals from the device.

20. The system of claim 18, wherein the RT is a portable reader.

21. The system of claim 18, wherein the RT is a fixed gate reader.

22. The system of claim 18, wherein the RT is an on-board vehicle reader.

23. The system of claim 18, wherein the RT is a surveillance reader.

24. The system of claim 1, wherein the microprocessor causes the transmitter to transmit the data signal at predetermined time intervals.

25. The system of claim 1, wherein the device is a tire tag that includes:

a deep sleep mode in which an R/C oscillator is incrementing a sleep register which provides periodic wake-up signals at predetermined intervals;

a lucid sleep mode wherein the microprocessor partially awakens and causes the sensor to measure and store the device parameter; and

a search mode wherein the microprocessor periodically partially awakens and further examines the received transmission to determine whether the transmission is a valid interrogation signal and, if so, fully awakens to an interrogation mode to respond to the valid interrogation signal.

26. The system of claim 25, wherein the tire tag remains in the search mode for a first predetermined period of time and then returns to the deep sleep mode for a second predetermined period of time.

27. The system of claim 25, wherein the RT commands the tire tag to transmit the measured parameter and thereafter commands the tire tag to enter the deep sleep mode.

28. The system of claim 1, wherein the microprocessor on a third periodic basis autonomously transmits an alarm signal to at least one remote reader/transceiver (RT) at the second location only when the last stored measured parameter falls outside of a predetermined threshold.

29. The system of claim 1, wherein the device is a tire tag, the system further comprising:

an antenna coupled to the microprocessor;

a remote reader/transceiver (RT) at the second location for transmitting forward link packets to the tag receiver; and

a reader processor (RP) at the second location for receiving return link packets from the tag transmitter and identifying the transmitting tire tag from data in the return link packets.

30. The system of claim 29, wherein the RP identifies the transmitting tire tag on the basis of a functional identification number that is transmitted by the tire tag.

31. The system of claim 29, wherein the RP identifies the transmitting tire tag on the basis of a unique tire tag serial number that is transmitted by the tire tag.

32. The system of claim 29, wherein the RP identifies the transmitting tire tag using a successive approximation routine (SAR).

33. The system of claim 32, wherein the SAR includes comparing a masked comparator value to a unique tag serial number.

34. The system of claim 33, wherein the SAR further includes sequentially incrementing the mask value by one until the unique tire tag serial number is found.

35. The system of claim 29, wherein the tire tag transmitter and the RT operate in the frequency range of about 902-928 MHz.

36. The system of claim 1, further including a tire patch mounted to the inner liner of a vehicle tire, wherein the tire tag is encapsulated in an epoxy and attached to tire patch.

37. The system of claim 36, wherein the tire patch is disposed on a sidewall of the vehicle tire.

38. The system of claim 1, wherein the device is a tire tag, the system further comprising:

a remote reader/transceiver (RT) at the second location for receiving data signals from the tire tag transmitter and transmitting command signals to the tire tag receiver; and

a frequency hopping circuit for causing the RT to transmit each command signal on a frequency different from the previous command signal to avoid interference with other devices operating in the same bandwidth.

39. A system for measuring a tire parameter comprising:

a tire tag disposed inside of a vehicle tire, the tire tag including:

a sensor for measuring one or more tire parameters;

a microprocessor coupled to the sensor for activating the sensor on a first periodic basis;

a memory in the microprocessor for storing the one or more tire parameters; and

a receiver coupled to the microprocessor, the microprocessor periodically partially awakening to examine, on a second periodic basis, a transmission and to at least partially identify the transmission as an interrogation signal from a reader/transceiver (RT) at the second location;

a search mode wherein the microprocessor partially awakens to further examine the partially identified interrogation signal and verify that the partially identified interrogation signal is a valid interrogation signal;

a transmitter coupled to the microprocessor; and

an interrogation mode wherein the microprocessor fully awakens and responds to the valid interrogation signal, via the transmitter, by at least transmitting the last stored data signal representing the measured parameter.

40. The system of claim 39, further comprising:

a reader/transmitter (RT) at the remote location for receiving data signals from the tire tag and transmitting command signals to the tire tag;

a reader processor (RP) for interpreting the data signals; and

a computer for communicating with the RP and enabling a user to access data from the tire tag.

41. The system of claim 40, wherein the RT is a portable reader that receives the most recently stored sensor data.

42. The system of claim 40, wherein the RT is a fixed gate reader that receives the most recently stored sensor data.

43. The system of claim 40, further comprising a tire database remote from the RT, wherein the RT transmits the most recently stored sensor data to the tire database.

44. The system of claim 40, wherein the RT is a surveillance reader that listens for data signals from the tire tag at locations including major intersections, vehicle-ready lines, shovel sites, crusher sites, dump sites, loading sites, maintenance yards, and tire shops.

45. The system of claim 40, wherein the command signals transmitted by the RT to the tire tag use amplitude shift key (ASK) modulation.

46. The system of claim 45, wherein the command signals are transmitted to the tire tag at a first rate.

47. The system of claim 46, wherein the first rate is about 15 Kbps.

48. The system of claim 40, wherein the tag transmitter includes up to four return link channels and uses frequency shift key (FSK) modulation to transmit the data signals to the RT.

49. The system of claim 48, wherein the data signals are transmitted from the tire tag to the RT at a second rate.

50. The system of claim 49, wherein the second rate is about 60 Kbps.

51. The system of claim 40, wherein the tire tag includes an alarm function that, at preset intervals, awakens the tire tag, examines the last stored tire parameters, determines if an alarm condition exists, and, if an alarm condition exists, transmits an alarm signal to the RT, all without external activation.

52. The system of claim 51, wherein the tire tag terminates the alarm signal transmission upon receipt of an acknowledgement from the RT.

53. The system of claim 51, wherein the tire tag rearms the alarm function when the alarm signal transmission is terminated.

54. The system of claim 51, wherein the alarm condition is determined by comparing the most recently stored tire parameters with stored thresholds.

55. The system of claim 54, wherein the alarm signal is transmitted if one of the tire parameters is outside one of the stored thresholds.

56. The system of claim 40, wherein the tire tag includes an autonomous transmission mode that, at preset intervals, causes the tire tag to awaken and transmit the last stored sensor measurements to the RT, and then returns to a deep sleep mode, all without external activation.

57. The system of claim 56, wherein the autonomous transmission mode only transmits the last stored sensor measurements when a device parameter falls outside of a predetermined threshold.

58. The system of claim 40, wherein the tire tag includes a tire history function that only downloads tire history data stored in the tire tag to the RT if the tire history data has not been previously transmitted to the RT.

59. The system of claim 40, wherein the tire tag includes a tire history function that downloads all of the tire history data stored in the tire tag to the RT.

60. The system of claim 40, wherein the RT requests data from specific memory locations in the tire tag.

61. The system of claim 40, wherein the tag transmitter includes a plurality of return link channels on which to transmit data to the RT.

62. The system of claim 61, wherein the RT sends a command signal to the tire tag designating the frequency of the return link channel on which to respond.

63. The system of claim 61, wherein the RT periodically searches the return link channels, determines which channel has the lowest received signal strength (RSS), and commands the tire tag to transmit on the return link channel having the lowest RSS.

64. The system of claim 40, wherein the RT assigns a temporary ID number to the tire tag.

65. The system of claim 40, wherein the command signals are sent over a spread-spectrum forward link including at least 50 channels.

66. The system of claim 40, wherein the RT transmits a command to the tire tag and then waits a predetermined period of time for a response.

67. The system of claim 40, wherein the tag further includes a first low power internal oscillator for generating a first clock signal.

68. The system of claim 67, wherein the first low power clock signal is used for incrementing a sleep register for determining when to exit a deep sleep mode.

69. The system of claim 67, wherein the first low power clock signal is used for operating the tag in the search mode.

70. The system of claim 40, wherein the tag further includes a second internal oscillator for generating a second clock signal.

71. The system of claim 70, wherein the second clock signal is used for operating the tag in the interrogation mode.

72. The system of claim 40, wherein the computer is a remote computer for storing the tire parameters.

73. The system of claim 72, wherein the remote computer is a personal computer (PC) running appropriate software to maintain a database that includes an archive of tag history data.

74. The system of claim 40, wherein data is communicated between one or more of the RT, the RP, and the computer via a communication channel selected from the group consisting of an RS-232 link, an Ethernet link, a wire link, a wireless link, an RF link, a cable link, a microwave link, a satellite link, and an optical link.

75. The system of claim 40, wherein the tire tag further comprises a kill tag function that allows a command from the RT to erase all data stored in the tag memory such that the tire tag will not respond to any external commands.

76. The system of claim 39, wherein the tire tag further comprises an erase function that erases all stored user level data and returns the tire tag to manufacturer level defaults.

77. The system of claim 39, wherein the tire tag includes an autonomous data collection function that, at preset intervals, cases the tire tag to partially awaken, take sensor measurements, store the sensor measurements, and return to a deep sleep mode, all without any external activation.

78. The system of claim 39, wherein the measured tire parameters include tire pressure and wherein the tire tag further comprises a turn-off function that enables the tag to recognize when the measured tire pressure is below a preselected pressure threshold and, while the pressure is below the preselected threshold, to cease storing and transmitting tag data to conserve power.

79. The system of claim 39, wherein the tire tag memory stores data including one of more of tire pressure data, tire temperature data, a unique tire identification number, a unique tag identification number, and tire history data including tire pressure and tire temperature data stored over a predetermined period of time.

80. The system of claim 39, wherein the data signals received from the tire tag include tag history data stored over a predetermined period of time.

81. The system of claim 39, wherein the tire tag includes a write function that enables a user to write data into the tire tag memory, including the wheel position of the tire tag, the vehicle number, the threshold tire parameter values, and user defined data.

82. The system of claim 39, wherein the tire tag has password protection to prevent unauthorized access thereto.

83. The system of claim 39, wherein the tire tag memory stores data including one or more of tag ID, vehicle ID, tire ID, tire position on a vehicle, number of tire revolutions, and calibration data for the sensor.

84. The system of claim 39, wherein the tire tag further comprises:

a printed circuit board (PCB) disposed within the vehicle tire, the PCB including first terminals, the sensor, the microprocessor, the memory, and the transmitter;

an antenna disposed in the vehicle tire and including second terminals, the first and second terminals being configured to electrically connect with each other to thereby electrically connect the antenna to the transmitter, the antenna being spaced from the PCB; and

potting material for encapsulating the PCB, the sensor, the microprocessor, the memory, the transmitter, and the antenna.

85. The system of claim 84, wherein the antenna is a dipole antenna.

86. The system of claim 85, wherein the dipole antenna includes first and second elements.

87. The system of claim 84, wherein the antenna is attached to the PCB such that the antenna is in a plane parallel to the plane of the PCB.

88. The system of claim 84, wherein the antenna is attached to the PCB such that the antenna is in a plane normal to the plane of the PCB.

89. The system of claim 84, further including at least one inductor placed in series with the first and second elements, respectively.

90. The system of claim 39, further including a tire patch mounted to the inner liner of the vehicle tire, wherein the tire tag is encapsulated in an epoxy and attached to tire patch.

91. The system of claim 90, wherein the tire patch is disposed on a sidewall of the vehicle tire.

92. A tire tag comprising:

a sensor for measuring at least one tire parameter and generating a data signal representing the measured parameter;

a microprocessor for causing the tire tag to enter a deep sleep mode in which a minimum number of electrical components are powered to conserve battery power;

the microprocessor, on a periodic basis, causing the tire tag to enter a lucid sleep mode in which certain of the electrical components are activated to cause the sensor to measure and store the at least one tire parameter; and

the microprocessor periodically partially awakening and looking for a forward link transmission and, if detected, causing the tire tag to determine whether the forward link transmission is a valid interrogation signal and, if so, causing the tire tag to enter an interrogation mode where the microprocessor activates all necessary electrical components to receive, process and respond to the valid interrogation signal.

93. A system for measuring a parameter of a device at a first location comprising:

a sensor for measuring the device parameter and generating a data signal representing the measured parameter;

a memory in the microprocessor for storing the generated data signal representing the measured parameter;

a microprocessor coupled to the sensor for activating the sensor on a first periodic basis to measure the device parameter, the microprocessor comparing the measured parameter with one or more parameter thresholds and generating an alarm signal if the measured parameter is outside of the one or more parameter thresholds; and

a transmitter coupled to the microprocessor for transmitting the alarm signal on a second periodic basis to a remote reader/transceiver (RT) without external activation.

94. The system of claim 93, wherein the microprocessor partially awakens, takes (on the first periodic basis) sensor measurements, stores the sensor measurements, and returns to a deep sleep mode, all without any external activation.

95. The system of claim 93, wherein the device is a tire tag disposed inside of a vehicle tire, and further comprising:

a printed circuit board (PCB) disposed within the vehicle tire, the PCB including first antenna terminals, the sensor, the microprocessor, the memory, and the transmitter;

an antenna disposed in the vehicle tire and including second antenna terminals, the first and second antenna terminals being configured to electrically connect with each other to thereby electrically connect the antenna to the transmitter, the antenna being spaced from the PCB; and

potting material for encapsulating the PCB, the sensor, the microprocessor, the memory, the transmitter, and the antenna.

96. An electronic tire management system (ETMS) comprising:

a sensor for measuring a tire parameter and generating a data signal representing the measured tire parameter;

a memory for storing one or more parameter thresholds;

a tag transmitter for transmitting an RF signal;

a microprocessor coupled to the sensor and the transmitter, the microprocessor activating the sensor at periodic intervals to measure the tire parameter, comparing the measured tire parameter with the one or more stored parameter thresholds, generating an alert signal if the measured parameter is outside of the one or more parameter thresholds, and, in response to the alert signal, causing the transmitter to transmit an alarm signal that indicates that the tire parameter is outside of the one or more parameter thresholds; and

a printed circuit board mounted in the tire and including the sensor, the memory, the tag transmitter, and the microprocessor.

97. A process for electronic tire management comprising:

mounting a tire tag on the inside of a tire;

causing the tire tag to enter a deep sleep mode;

periodically causing the tire tag to partially awaken on a first periodic basis to measure one or more parameters of the tire;

storing the measured parameters;

returning the tire tag to the deep sleep mode; and

periodically causing the tire tag to partially awaken to determine, on a second periodic basis, if a received transmission is a valid interrogation signal and, if so, fully awakening and responding to the valid interrogation signal, via the transmitter, by at least transmitting the measured parameters to a remote reader/transceiver (RT).

98. The process of claim 97, further including transmitting on a third periodic basis at least the last stored measured parameters to the remote reader/transceiver (RT) without external activation.

99. A process for electronically monitoring tire parameters with a tire tag, the process comprising:

sleeping in a deep sleep mode for a predetermined period of time;

awakening to a lucid sleep mode to detect if a transmission is likely a forward link packet from a remote reader/transceiver (RT);

entering a search mode to determine if the transmission is a valid forward link packet;

entering an interrogation mode if a valid forward link packet is detected and responding to the valid forward link packet; and

returning to the deep sleep mode.

100. A method for electronically monitoring tire parameters with a tire tag, the method comprising:

causing the tire tag to enter a deep sleep mode to conserve power; and

automatically awakening the tire tag from the deep sleep mode on a first periodic basis to measure and store the tire parameters;

automatically awakening the tire tag from the deep sleep mode on a second periodic basis to detect if a transmission is a valid forward link packet from a remote reader/transceiver (RT) and, if so, responding to the valid forward link packet; and

returning the tire tag to the deep sleep mode.

101. A tire tag comprising:

a microprocessor programmed to:

store the cold fill temperature of a vehicle tire;

measure the hot inflation pressure and temperature of the vehicle tire during operation of the tire;

calculate an equivalent cold pressure of the tire using the ideal gas equation:

$$PV = nRT \qquad \text{where}$$

P = pressure exerted by the gas in the tire (a variable);

V= volume of the chamber containing the gas (essentially a constant);

n = number of moles of gas contained within the tire (a constant);

R = a constant specific to the gas contained within the tire;

T = temperature of the gas contained within the tire (a variable); and

$$T1/P1 = T2/P2 \qquad \text{where}$$

P1 = pressure at time t1 (cold fill reference pressure)

P2 = pressure at time t2 (current hot pressure)

T1 = temperature at time t1 (cold fill reference temperature)

T2 = temperature at time t2 (current hot temperature); and

compare the calculated equivalent cold pressure with a stored Target Cold Fill Inflation Pressure specified by the manufacturer of the tire to determine if the tire is properly inflated during operation.